Thesis/
Reports
Woods,
S. W.

Calibration of Streamflow Gauging Stations at the Tenderfoot Creek Experimental Forest

Final Technical Report

CALIBRATION OF STREAMFLOW GAUGING STATIONS AT THE TENDERFOOT CREEK EXPERIMENTAL FOREST

USDA Joint Venture Agreement No. 02-JV-11222022-183

Submitted to:

Dr. Ward McCaughey

Rocky Mountain Research Station

Forestry Sciences Laboratory

Missoula MT 59812

Prepared by:

Dr. Scott W. Woods, Principal Investigator

Department of Ecosystem and Conservation Sciences

College of Forestry and Conservation

The University of Montana

Missoula MT 59812

June 2007

RMRS Library
USDA Forest Service
JUL 5 2007
240 W Prospect Rd
Fort Collins CO 80526

Summary

We used tracer based methods to calibrate eleven streamflow gauging stations at the Tenderfoot Creek Experimental Forest in western Montana. At six of the stations the measured flows were consistent with the existing rating curves. At Lower and Upper Stringer Creek, Upper Sun Creek and Upper Tenderfoot Creek the published flows, based on the existing rating curves, were higher than the actual flows, while at Lower Sun Creek the published flows were lower than the actual flows. At the Lower and Upper Stringer Creek and Upper Tenderfoot Creek sites we recommend that the flumes be examined for evidence of the cause of the inaccurate measurements and that appropriate remedial action be taken. Specific points include 1) verifying that the flume geometry is correct, that the flume is straight and horizontal, and that the flume has not been damaged; 2) clearing debris from within or around the flume; and 3) comparing electronically recorded stage values to those observed on the flume staff plate. In the event that there is no evidence of the cause of the observed measurement discrepancy we recommend additional measurements at these flumes to verify the measurements already obtained and to develop new rating curves. At the Upper Sun Creek we recommend that additional measurements be taken across a wider range of flows so that a new rating curve can be developed. At Lower Sun Creek we recommend that the flume installation be checked for leaks and appropriate remedial action taken.

Introduction

The Tenderfoot Creek Experimental Forest was established in 1961 and is representative of the lodgepole pine (*Pinus contorta*) forests found east of the Continental Divide across much of Montana, southwest Alberta, and Wyoming. Hydrologic and climatic monitoring sites and equipment were installed at TCEF in the early 1990s to develop pre-treatment baseline information for the Tenderfoot Research Project, which is testing an array of management treatments for regenerating and restoring healthy lodgepole pine forests through emulation of natural disturbance processes. The hydrologic monitoring network at TCEF includes eleven streamflow gauging stations. Two of the gauging stations lie along Tenderfoot Creek and the other nine lie along tributary streams (Figure 1). Sun Creek and Stringer Creek, the two tributaries along which silvicultural treatments have been completed, have two gauging stations, one immediately downstream from the treated area and the other at the tributary outlet to Tenderfoot Creek. Flow at ten of the gauging stations is measured in flumes while the flow at the Upper Sun Creek station is measured at a rated cross section. Flow in the flumes is calculated using standard rating equations while the flow at Upper Sun

Creek is calculated using a site-specific rating curve equation that was developed in the late 1990s (Table 1). Median flows at the gauging stations range from 0.01 cubic feet per second (cfs) at Lonesome Creek to 3.3 cfs at Lower Tenderfoot Creek (Table 2).

Table 1. *Flume type and rating equations used to calculate discharge at the gauging stations at the Tenderfoot Creek Experimental Forest. W is the width of the flume throat and H is the staff gage reading.*

Station	Flume type	Rating Equation
Upper Tenderfoot	4' Parshall	$Q=4WH^{1.5222}W^{0.026}$
Lower Sun	4" Parshall	$Q=4WH^{1.5222}W^{0.026}$
Upper Sun	Open Channel	$Q=1.10654H-9.79070H^2+20.39369H^3-2.79459H^4-3.25692H^5$
Spring Park	2.5' Parshall	$Q=4WH^{1.5222}W^{0.026}$
Bubbling	3.5' H-flume	$Q= -0.00245H^5+0.02321H^4+0.40881H^3+2.04595H^2+0.22921H$
Upper Stringer	3.5' H-flume	$Q= -0.00245H^5+0.02321H^4+0.40881H^3+2.04595H^2+0.22921H$
Lower Stringer	4' H-flume	$Q=0.00368H^5-0.0257H^4+0.50010H^3+2.08520H^2+0.29353H$
Lower Tenderfoot	10' Parshall	$Q=(3.6875(W)+2.5)H^{1.6}$
Pack	2' Parshall	$Q=4WH^{1.5222}W^{0.026}$
Passionate	4' Cipolletti	$Q=3.367WH^{3/2}$
Lonesome	3' H-flume	$Q=-0.02504H^5+0.18345H^4-0.00273H^3+2.44994H^2-0.02459H$

The sum of the daily flows for tributary streams contributing flow to the main stem of Tenderfoot Creek at the Lower Tenderfoot Creek gage is generally less than the daily flow at the Lower Tenderfoot Creek gauging station. This shortfall may be due to inflows to Tenderfoot Creek above the gage that are not measured, such as small ephemeral channels, seeps and groundwater discharge. Alternatively, the measured flows at one or more of the gauging stations may be erroneous. Errors in discharge measurements obtained using flumes are generally less than ±2%, but can be greater if the dimensions of the flume are incorrect, if the flume becomes distorted during installation, if the flume is not level, or if the head measurement used to calculate the flow is inaccurate. Discharge measurements at rated cross sections are subject to greater error, generally at least ±5% because the measurements on which the rating curve is based are themselves subject to errors and because the dimensions of the rated cross section can change over time due to scouring or deposition of sediment within or near to the rated cross section. In order to verify the accuracy of the flow measurements obtained at each of the eleven gauging stations at TCEF we conducted flow calibration measurements during the early summer high flow periods in 2003 and 2005. This report presents the results of those measurements and, where appropriate, provides recommendations for modifying the existing rating curves to improve measurement accuracy.

Table 2. *Minimum (Q_{min}), 10th (Q_{10}), 25th (Q_{25}), 50th (Q_{50}, median), 75th (Q_{75}), 90th (Q_{90}) percentile and maximum (Q_{max}) daily mean discharge for period of record at gauging stations at the Tenderfoot Creek Experimental Forest.*

Flume	Q_{min}	Q_{10}	Q_{25}	Q_{50}	Q_{75}	Q_{90}	Q_{max}
Pack	0.10	0.10	0.20	0.30	0.80	4.10	20.08
Passionate	0.00	0.01	0.10	0.10	0.20	1.48	8.40
L.Stringer	0.32	0.40	0.40	0.60	1.20	5.71	61.80
U. Stringer	0.10	0.10	0.10	0.20	0.60	3.82	26.74
Spring Park	0.10	0.30	0.40	0.50	0.80	3.20	34.90
L. Sun	0.10	0.10	0.20	0.34	0.90	2.60	26.30
U. Sun	0.05	0.05	0.10	0.25	0.88	2.05	8.70
L. Tenderfoot	1.10	2.00	2.50	3.30	7.70	31.50	264.70
U. Tenderfoot	0.10	0.20	0.20	0.40	0.86	3.30	29.70
Bubbling	0.00	0.10	0.20	0.20	0.55	3.16	27.30
Lonesome	0.000	0.000	0.000	0.01	0.05	1.08	19.60

Methods

Calibration of the ten flumes and the rated cross section at Upper Sun Creek was conducted by measuring the discharge immediately upstream or downstream from the gauging station and comparing the measured flow (Q_m) to the calculated flow (Q_c) obtained using the observed stage height at the time of measurement and the appropriate rating curve equation (Table 1, Appendix I). Flow measurements were obtained on the falling limb of the spring runoff peak flows in 2003 and 2005. At least two measurements were obtained at all eleven gauging station and three or more measurements were obtained at nine stations. Since access to TCEF is generally not possible until snowmelt is almost complete we were unable to obtain measurements on the rising limb of the snowmelt hydrograph or during the annual peak flow. Current meter measurements of velocity and discharge are not appropriate for the steep, rocky channels that occur at TCEF. Tracer based methods using either a dye or salt tracer offer a more practical and accurate approach to obtaining the desired measurements, and we used this approach when conducting our measurements at the TCEF gauging stations.

Measurements obtained in 2003 were conducted using a dye dilution approach in accordance with Kilpatrick and Cobb (1967). The dye was a 20% active solution of Rhodamine WT diluted to a concentration of 0.1, 0.2, 0.4 or 0.8 x 10^7 $\mu g.L^{-1}$ using a serial dilution approach. The required dye concentration was determined from Figure 9 of Kilpatrick and Cobb (1985) based upon the estimated stream discharge and a desired injection rate of ~50 $ml.min^{-1}$. Dye injection was conducted using a portable ceramic metering pump (Fluid Metering Inc., Syosset, New York), which has an accuracy of ±1%.

Dye concentrations in the stream were measured with a Turner Designs 10-AU field fluorometer with a continuous flow cell, data logging facility and automatic temperature compensation (Turner Designs Inc., Sunnyvale, California). Dye injection continued until at least 15 minutes after the dye concentration in the stream had reached steady state. Discharge (Q, $ft^3.s^{-1}$) was calculated from:

$$Q = \frac{(5.89 \times 10^{-7}) q.C}{c}$$

where q is the dye injection rate ($ml.min^{-1}$), C is the injected dye concentration ($\mu g.L^{-1}$) and c is the measured steady-state dye concentration in the stream ($\mu g.L^{-1}$).

Measurements obtained in 2005 were conducted using a salt dilution approach in accordance with Moore (2005). Salt dilution was used instead of dye dilution because we had experienced repeated equipment failure problems when using the dye dilution method in 2003. A known volume and concentration of salt (NaCl) solution was introduced into the stream as a near-instantaneous "slug" and the temporary increase in electrical conductivity (EC) due to the passage of the salt plume was measured every 1 second at a downstream location using a portable EC meter with data logging facility. Measurements were continued until the EC returned to background levels. The discharge Q ($ft^3.s^{-1}$) was calculated from:

$$Q = \frac{V}{k.\Delta t.\sum [EC(t) - EC_{bg}]}$$

where V is the volume of salt solution added (ft^3), k is a calibration constant ($cm.\mu S^{-1}$), Δt is the time increment of the conductivity measurements (seconds), EC(t) is the electrical conductivity at time t ($\mu S.cm^{-1}$) and EC_{bg} is the background electrical conductivity ($\mu S.cm^{-1}$) in the stream. The calibration constant, k, is the slope of the relationship between relative concentration and EC, and it was determined using the double dilution method described by Moore (2004).

Data Analysis

The error in flow measurements obtained using fluorescent dye and a constant rate injection can be as high as 6% but is typically less than 2% (Kilpatrick et al., 1967). Measurements based on slug injection of a salt solution are typically less than 5%. For the

purposes of analysis we assumed that both methods had a potential error of ±5%. The error in the calculated discharge was assumed to be ±2% in the flumes and ±5% at the rated cross section at Upper Sun Creek. If the difference between the measured and calculated flows ($Q_m - Q_c$) was greater than the sum of the errors in both measured and calculated flows then the difference was judged to be real, indicating that the calculated flow value was erroneous.

Results and Discussion

Pack Creek

The 2-foot Parshall flume at the Pack Creek gauging station is rated to 44 cfs but the maximum mean daily flow of record is just 20.08 cfs (Table 2, Appendix I). All of the flow measurements at the gauging station on Pack Creek, which were obtained at calculated flows of 1.6, 4.1 and 4.7 cfs, exceeded the 75th percentile[1] of the mean daily flow and the highest measurement exceeded the 90th percentile of the mean daily flow (Table 2, Figure 2). For the measurements obtained at 1.6 and 4.1 cfs, the difference between the measured flow and the calculated flow was greater than the total error in the measurements, indicating that the flume flow was inaccurate. However, at 1.6 cfs Q_m was greater than Q_c while the opposite was true at 4.1 cfs. Given the lack of consistency in the results of the three calibration measurements, and the fact that these measurements encompassed only a limited range of the total range of flows, there is insufficient evidence to support a change to the existing rating curve for the Pack Creek gauging site.

Passionate Creek

The 4-foot Cipolletti weir at the Passionate Creek gauging station is rated to 39 cfs, but the highest mean daily flow of record is just 8.40 cfs (Table 2, Appendix I). All three flow measurements at Passionate Creek were greater than the 75th percentile of mean daily flows and two of the measurements exceeded the 90th percentile (Table 2, Figure 3). Only one of the three flow measurements differed from the calculated flows by more than the total error in the measurements. We conclude that the flume at the Passionate Creek gauging site is performing properly within the range of flows included in this study and that no corrective action is required.

[1] The 75th percentile is the discharge that is equal to or greater than 75% of all mean daily flow values in the period of record. Flows greater than the 75th percentile are generally regarded as "above normal".

Lower Stringer Creek

The 4-foot H flume at the Lower Stringer Creek gauging station is rated to 63.7 cfs and the highest mean daily flow of record is 61.80 cfs (Table 2, Appendix I). All four flow measurements at Lower Stringer Creek were greater than the 75th percentile of mean daily flows and two measurements exceeded the 90th percentile (Table 2, Figure 4). Two of the flow measurements differed from the calculated flows by more than the total error in the measurements and the results suggest that flows are currently being overestimated by 0.25 – 0.45 cfs when the discharge at the flume exceeds 3.5 cfs (Figure 4). An overestimate of flow in a flume may be caused by an improper flume installation, by damage to the flume following installation, by the presence of debris in the flume throat, or by inaccurate measurement and recording of the stage height in the flume. We recommend that the Lower Stringer Creek flume be examined for evidence of the cause of the inaccurate measurements. Specific points to address include 1) verifying that the flume geometry is correct, that the flume is straight and horizontal, and that the flume has not been damaged; 2) clearing debris from within or around the flume; and 3) comparing electronically recorded stage values to those observed on the flume staff plate. In the event that there is no evidence of the cause of the observed measurement discrepancy we recommend additional measurements at this flume to verify the measurements already obtained.

Upper Stringer Creek

The 3.5-foot H flume at the Upper Stringer Creek gauging station is rated to 42.5 cfs, but the highest mean daily flow of record is just 26.74 cfs (Table 2, Appendix I). All three flow measurements at Upper Stringer Creek were greater than the 75th percentile of mean daily flows and one exceeded the 90th percentile (Table 2, Figure 5). Two of the flow measurements differed from the calculated flows by more than the total error in the measurements and the magnitude of the difference between the measured and calculated flow increased with increasing discharge. Similar to Lower Stringer Creek, the results suggest that flows are currently being overestimated by 0.2 – 0.5 cfs when the discharge at the flume exceeds 2.5 cfs (Figure 4). As stated previously, an overestimate of flow in a flume may be caused by an improper flume installation, by damage to the flume following installation, by the presence of debris in the flume throat, or by inaccurate measurement and recording of the stage height in the flume. We recommend that the Upper Stringer Creek flume be examined for evidence of the cause of the inaccurate measurements. The same issues should be addressed at this flume as were previously discussed for the Lower Stringer Creek flume.

Spring Park Creek

The highest mean daily flow of record at the 2.5-foot Parshall flume at the Spring Park Creek gauging station is 34.9 cfs, 83% of the maximum range of 41.7 cfs (Table 2). Only two measurements were obtained at Spring Park Creek, and neither differed from the calculated flow by more than the total error in the measurements (Figure 6). We therefore conclude that the flume at the Spring Park Creek gauging site is performing properly within the range of flows included in this study and that no corrective action is required.

Lower Sun Creek

The 4-foot Parshall flume at the Lower Sun Creek gauging station is rated to 90.6 cfs, but the highest mean daily flow of record is just 26.30 cfs (Table 2, Appendix I). All four flow measurements at Lower Sun Creek were greater than the 75th percentile of mean daily flows and two exceeded the 90th percentile (Table 2, Figure 7). The two lowest flow measurements, 2.52 and 1.17 cfs, exceeded the calculated flows by more than the total error in the measurements, indicating that flows are currently being under-estimated (Figure 7). We also note that, historically, the mean daily flows at Lower Sun Creek at baseflow have often been less than the corresponding flows at Upper Sun Creek (Figure 8). Given the confined nature of Sun Creek in its upper reaches, it is highly likely that the stream is gaining between the two gauging stations, so that base flows at Lower Sun Creek should be higher than those at Upper Sun Creek. The apparent underestimate of low flows at Lower Sun Creek could indicate that water is leaking around the flume. We recommend that the site be checked for leaks around or under the flume structure. In addition, the flume installation should be checked for evidence of improper installation or damage, and the recorded stage values should be checked against direct observations of the stage on the flume staff plate.

Upper Sun Creek

The cross section at the Upper Sun Creek gauging station is rated to 5.67 cfs, 35% less than the highest daily mean flow of record of 8.70 cfs (Table 2, Appendix I). All three flow measurements at Upper Sun Creek were greater than the 75th percentile of mean daily flows and two exceeded the 90th percentile (Table 2, Figure 9). In all three cases the difference between the measured and calculated flows exceeded the total error in the measurements. In all three cases the measured values were lower than the calculated values, indicating that flows are currently being overestimated by 0.5 to 1.0 cfs. Overestimation of

flows at the Upper Sun Creek site most likely reflects a change in the geometry of the cross sectional profile since the site was installed. Such changes are fairly common in uncontrolled stream cross sections. Given the limited range of values over which flows were measured (2.63 to 3.61 cfs) it is not possible to determine a new rating equation for the entire range of flows that occur at this site. We recommend obtaining additional flow measurements in the 0 to 1cfs and 4.5 to 6 cfs ranges, after which a new rating curve should be developed.

Lower Tenderfoot Creek

Lower Tenderfoot Creek, which is located at the downstream boundary of TCEF, has the highest flows of all the gauging stations included in this study. The 10-foot Parshall flume at the Lower Tenderfoot gauging station is rated to 517 cfs, although the highest mean daily flow of record is just 265 cfs (Table 2, Appendix I). Only two measurements were obtained at the Lower Tenderfoot Creek flume. However neither differed from the calculated flow by more than the total error in the measurements (Figure 10). We therefore conclude that the flume at the Lower Tenderfoot Creek gauging site is performing properly within the range of flows included in this study and that no corrective action is presently required.

Upper Tenderfoot Creek

The 4-foot Parshall flume at the Upper Tenderfoot Creek gauging station is rated to 90.6 cfs, but the highest mean daily flow of record is just 29.70 cfs (Table 2, Appendix I). All three flow measurements at Lower Sun Creek were greater than the 75th percentile of mean daily flows but none exceeded the 90th percentile (Table 2, Figure 11). Two of the three measurements differed from the calculated flow by more than the total error in the measurements, indicating that flows are currently being overestimated by 0.1 to 0.3 cfs when flows are in the 1 to 4 cfs range. As stated previously, an overestimate of flow in a flume may be caused by an improper flume installation, by damage to the flume following installation, by the presence of debris in the flume throat, or by inaccurate measurement and recording of the stage height in the flume. We recommend that the Upper Tenderfoot Creek flume be examined for evidence of the cause of the inaccurate measurements. The same issues should be addressed at this flume as were previously discussed for the Lower Stringer Creek flume.

Bubbling Creek

The 3.5 foot H flume at Bubbling Creek is rated to 42.5 cfs, but the highest mean daily flow of record is just 27.3 cfs (Table 2, Appendix I). All three measurements exceeded

the 75th percentile of mean daily flows and two exceeded the 90th percentile (Figure 12). Only the highest measurement differed from the calculated flow by more than the total error in the measurement. We conclude that the flume at the Bubbling Creek gauging site is performing properly within the range of flows included in this study and that no corrective action is presently required.

Lonesome Creek

The 3-foot H flume at Lonesome Creek is rated to 30.7 cfs, although the highest flow of record is just 19.6 cfs (Table 2, Appendix I). All three measurements exceeded the 75th percentile of mean daily flows and two exceeded the 90th percentile (Figure 13). Two measurements differed from the calculated flow by more than the total error in the measurements, and both indicated that the actual flow was higher than the flow calculated from the flume rating curve. However the third measurement, conducted at a similar flow to the second highest measurement, did not indicate a discrepancy. Given the lack of consistency in the results of the three calibration measurements, and the fact that these measurements encompassed only a limited range of the total range of flows, there is insufficient evidence to support a change to the existing rating curve for the Lonesome Creek gauging site.

References

Farnes, P.E. and W.W. McCaughey. 1995. Hydrologic and geologic characterization of Tenderfoot Creek Experimental Forest, Montana. Unpublished Report. Bozeman, MT: Forestry Sciences Laboratory, Montana State University. 200 pp.

Kilpatrick F.A., W.W. Sayre and E.V. Richardson, 1967. Flow measurement with fluorescent tracers: a discussion. Journal of Hydraulics. American Society of Civil Engineers HY4: 298 – 308.

Kilpatrick F.A. and E.D. Cobb, 1985. Measurement of discharge using tracers. Techniques of water resources investigations of the United States Geological Survey. Chapter A16, Book 3, Applications of Hydraulics. United States Geological Survey, Washington DC. 52 p.

Moore R.D., 2004. Introduction to salt dilution gauging for streamflow measurement, Part II: Constant rate injection. *Streamline Watershed Management Bulletin* 8: 11 - 14.

Moore R.D., 2005. Introduction to salt dilution gauging for streamflow measurement, Part III: Slug injection using salt in solution. *Streamline Watershed Management Bulletin* 8: 1- 6.

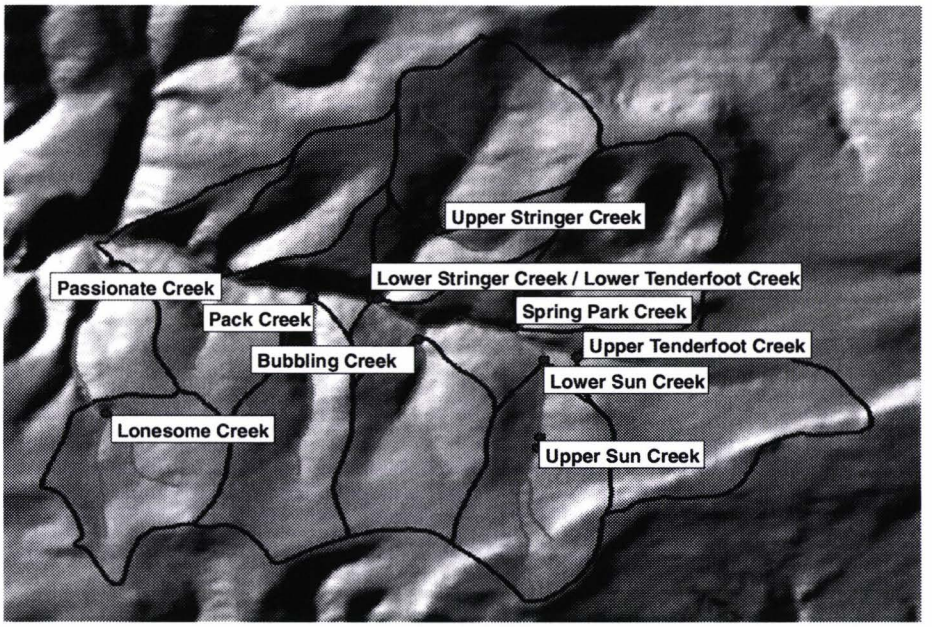


Figure 1. Location map of the streamflow gauging stations at the Tenderfoot Creek Experimental Forest.

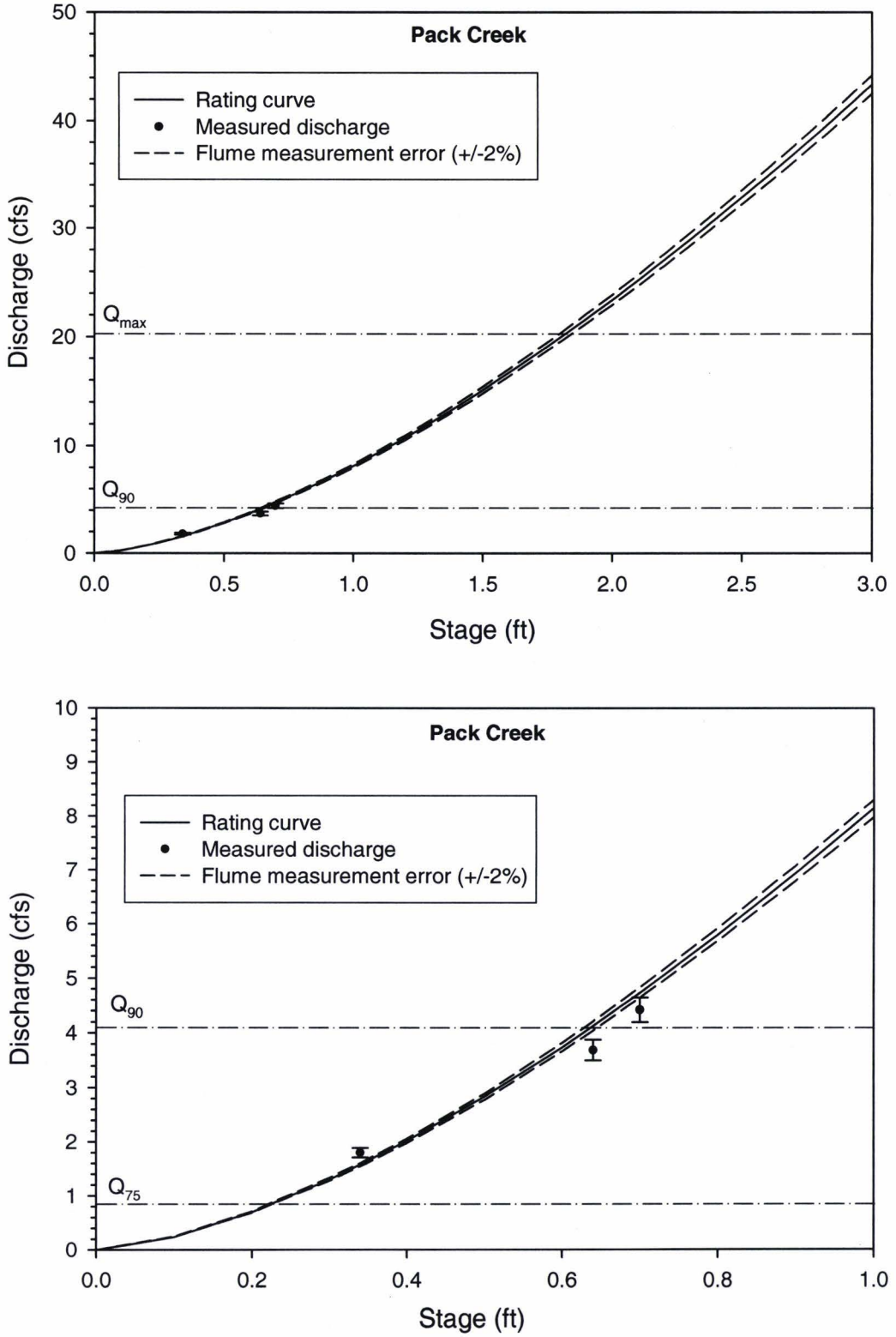


Figure 2. Stage rating curve and measured flows at Pack Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

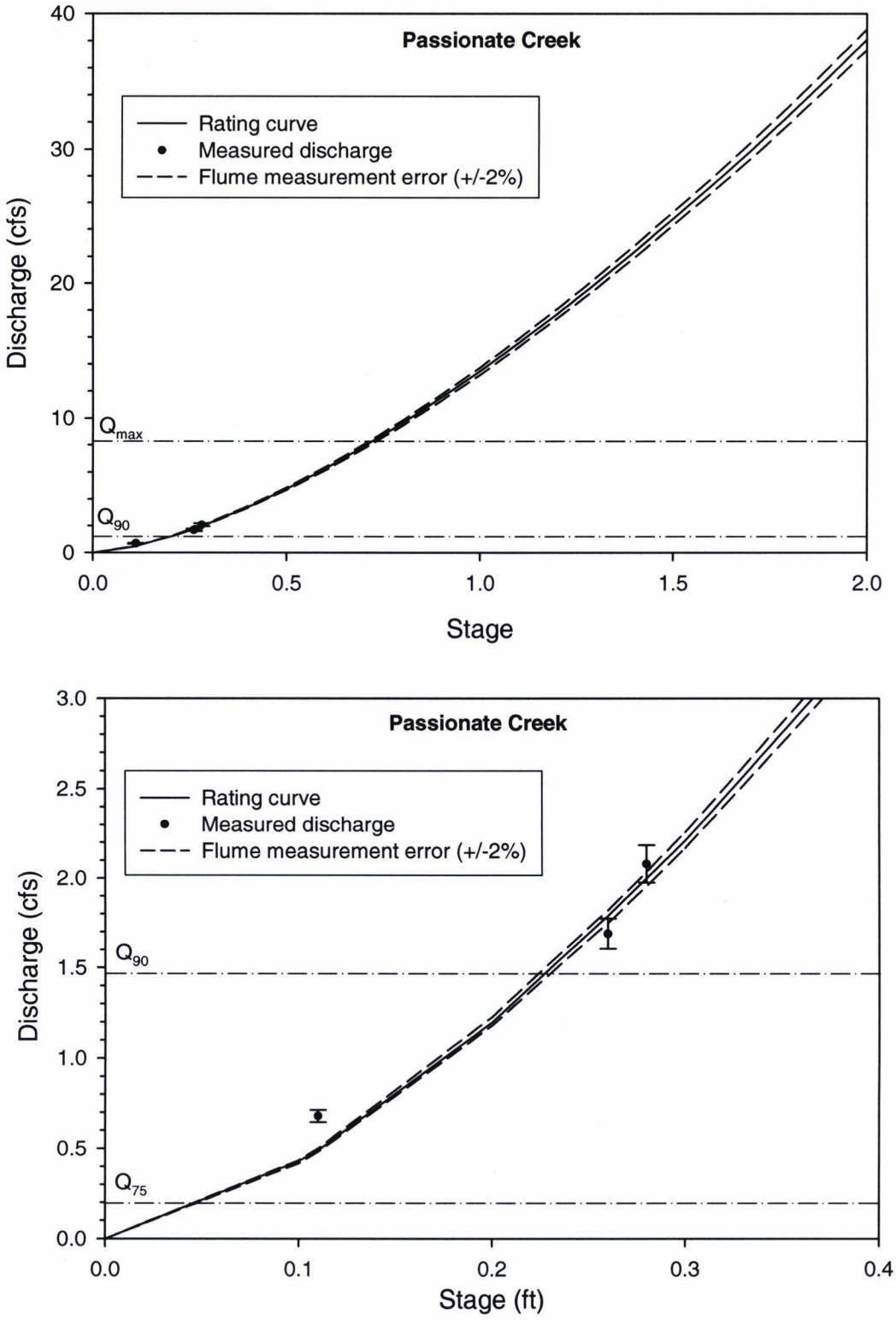


Figure 3. Stage rating curve and measured flows at Passionate Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

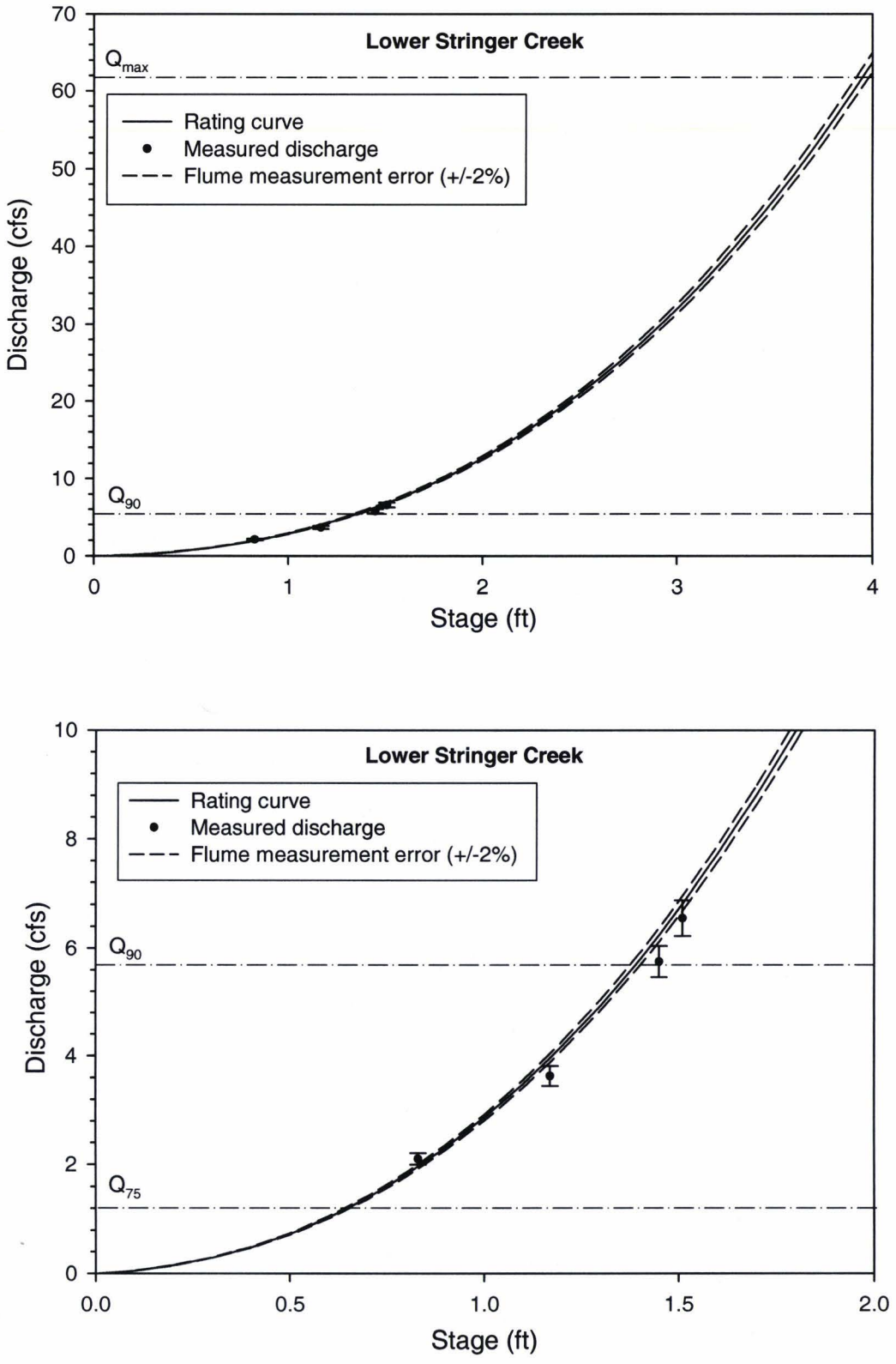


Figure 4. Stage rating curve and measured flows at Lower Stringer Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

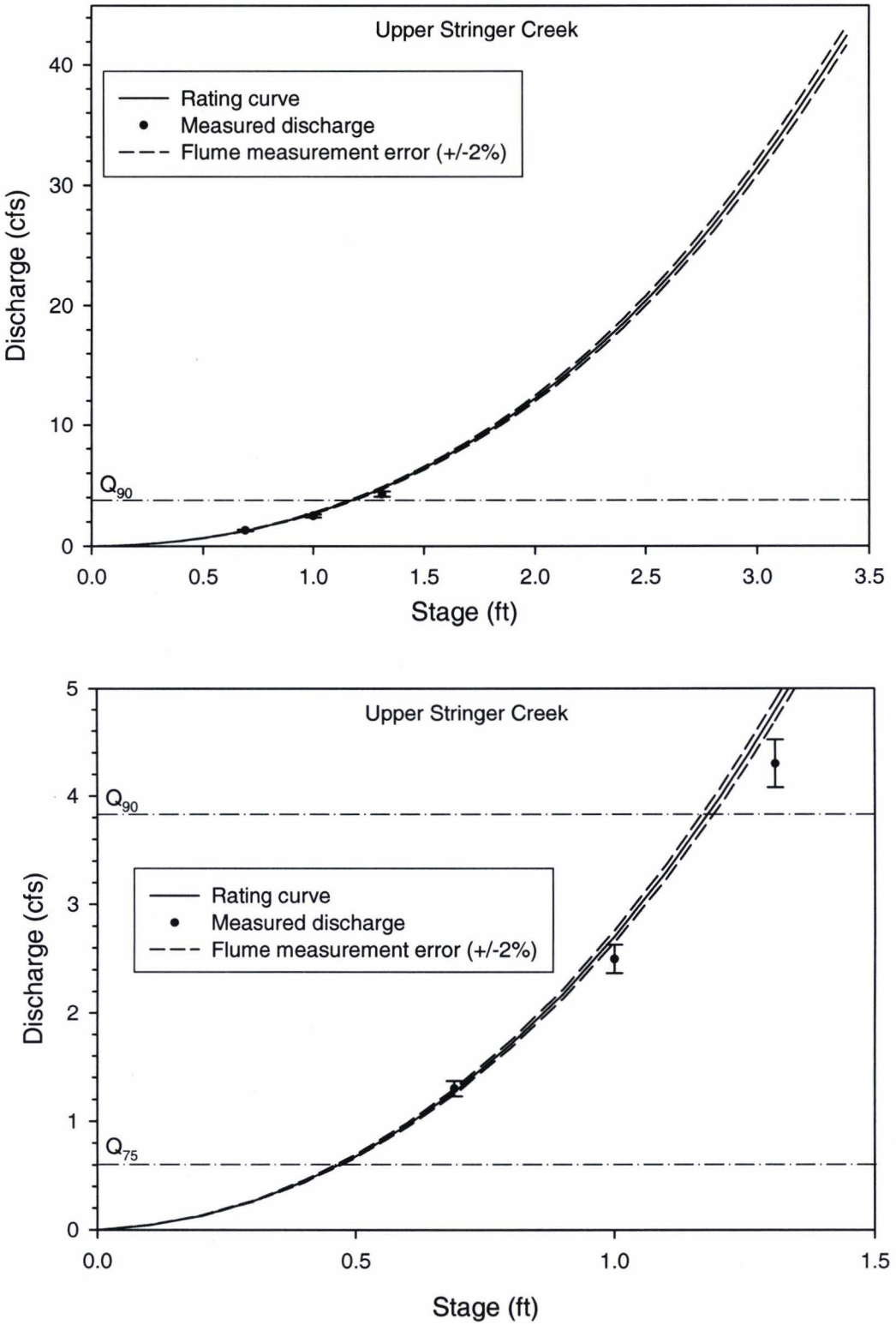


Figure 5. Stage rating curve and measured flows at Upper Stringer Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

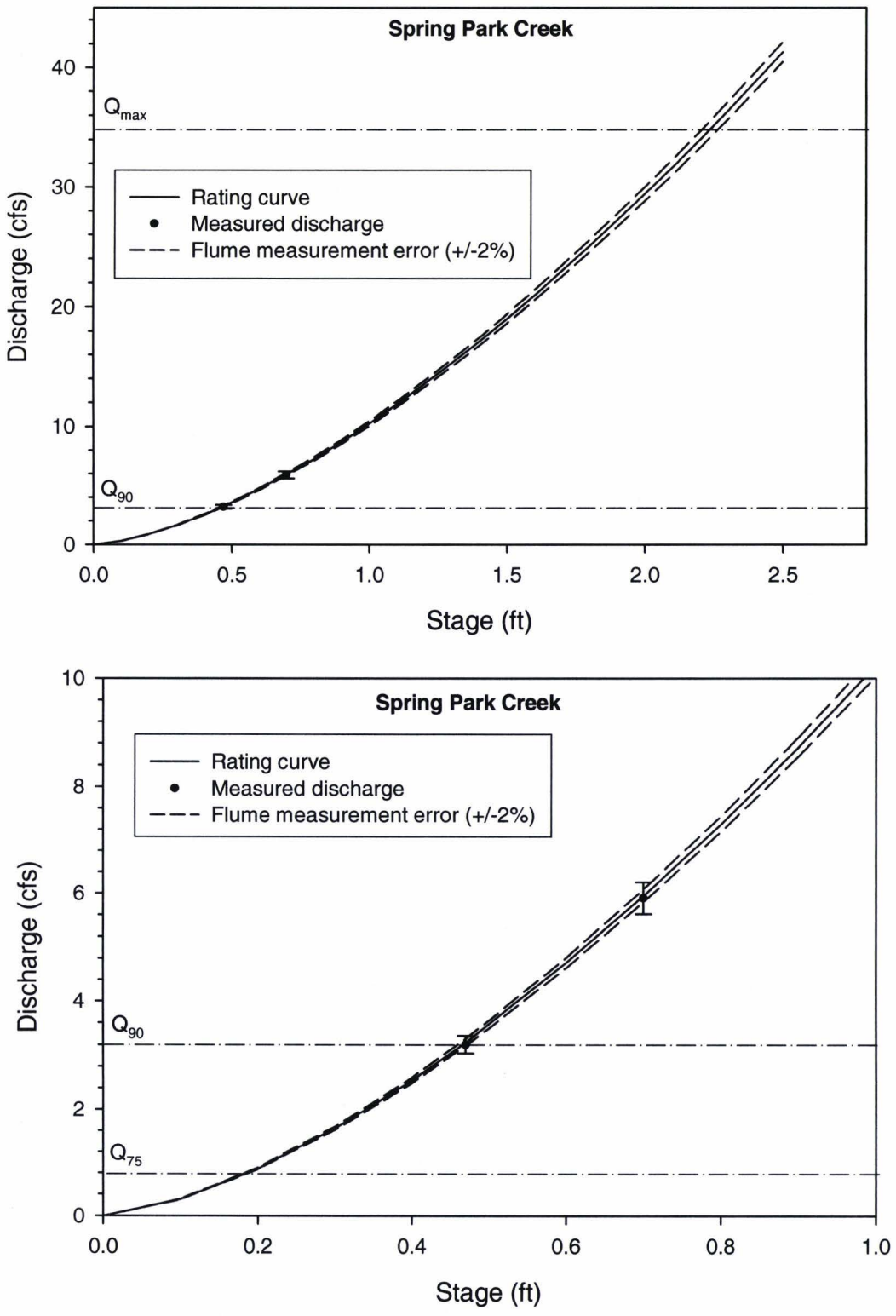


Figure 6. Stage rating curve and measured flows at Spring Park Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

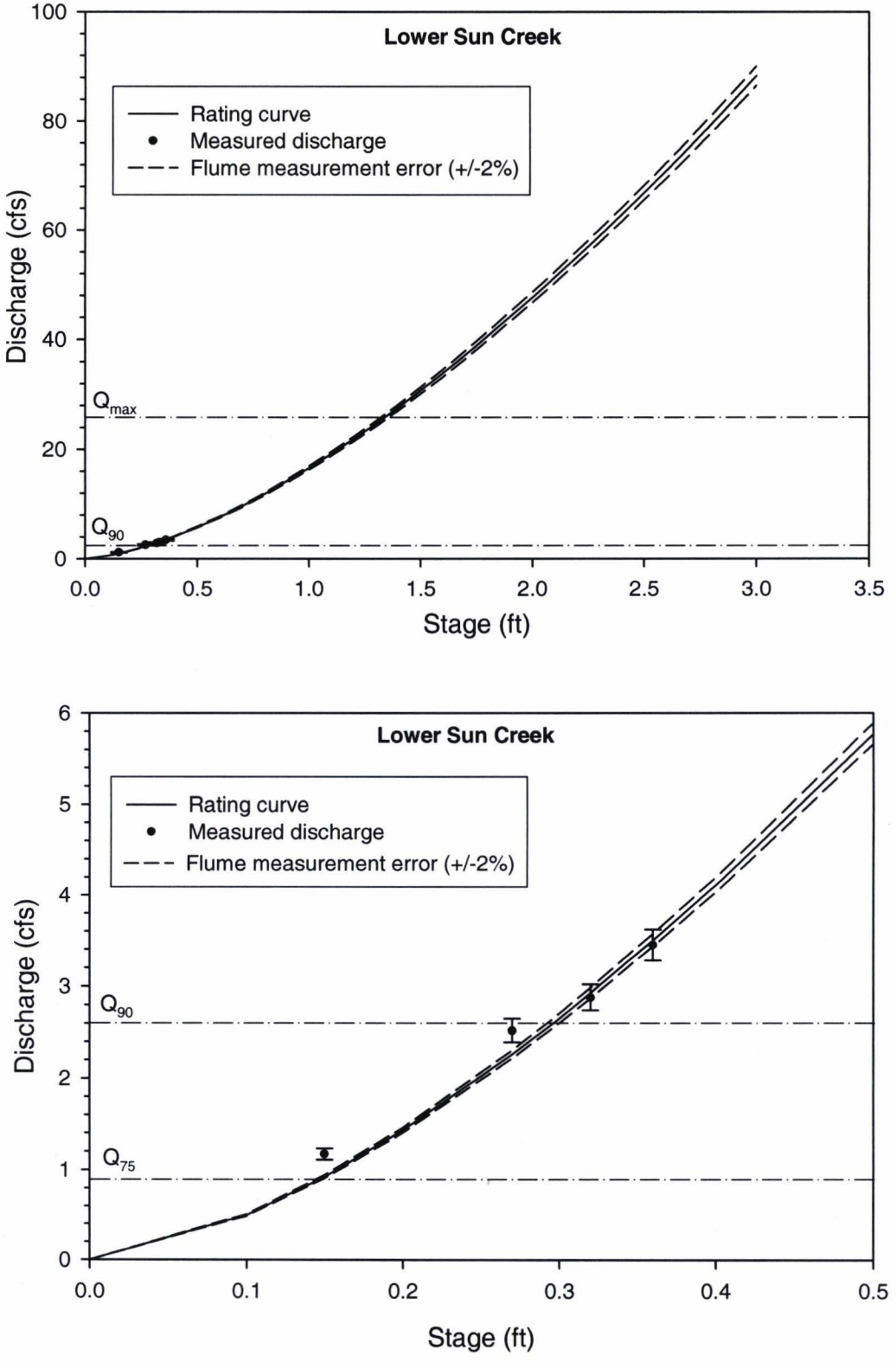


Figure 7. Stage rating curve and measured flows at Lower Sun Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

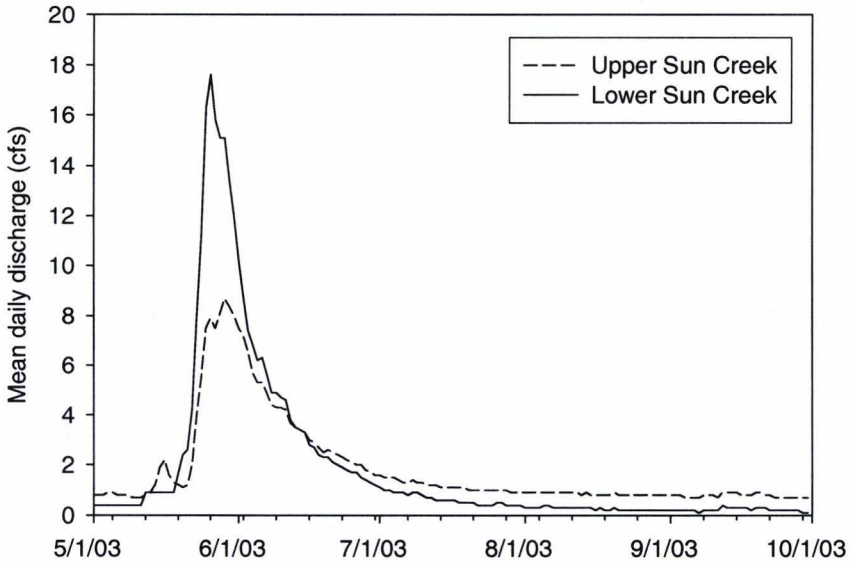


Figure 8. Mean daily discharge at Upper and Lower Sun Creek gauging sites, 1 May – 30 September 2003.

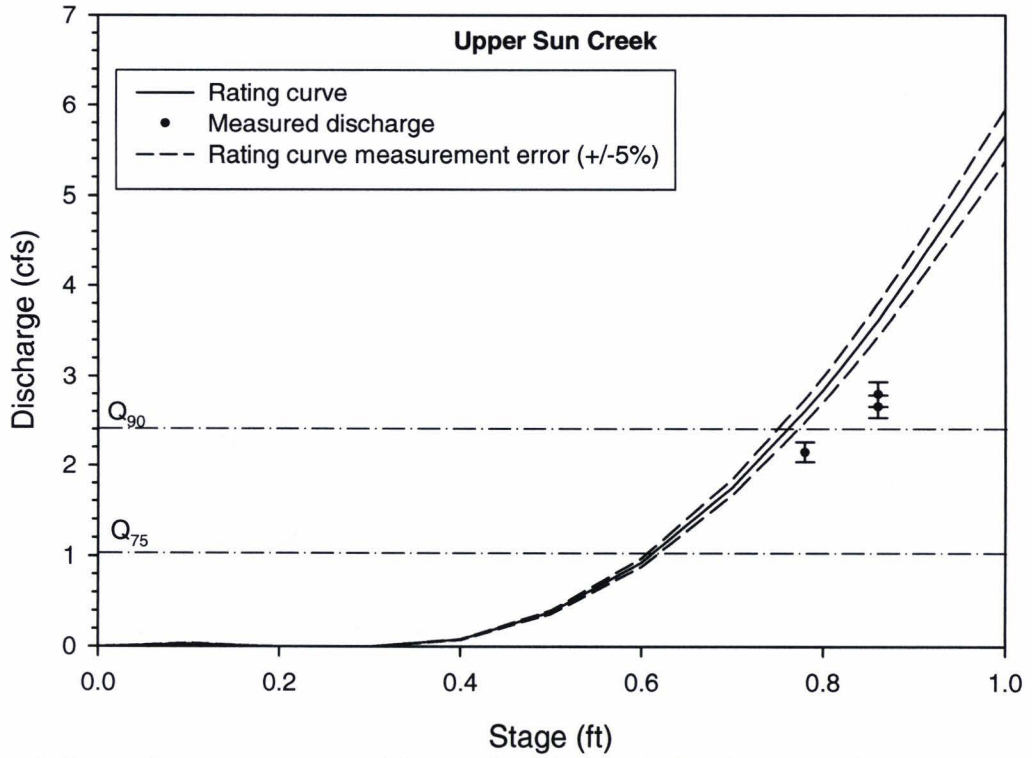


Figure 9. Stage rating curve and measured flows at Upper Sun Creek. Error in cross section rating curve (indicated by dashed lines) is ±5% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows.

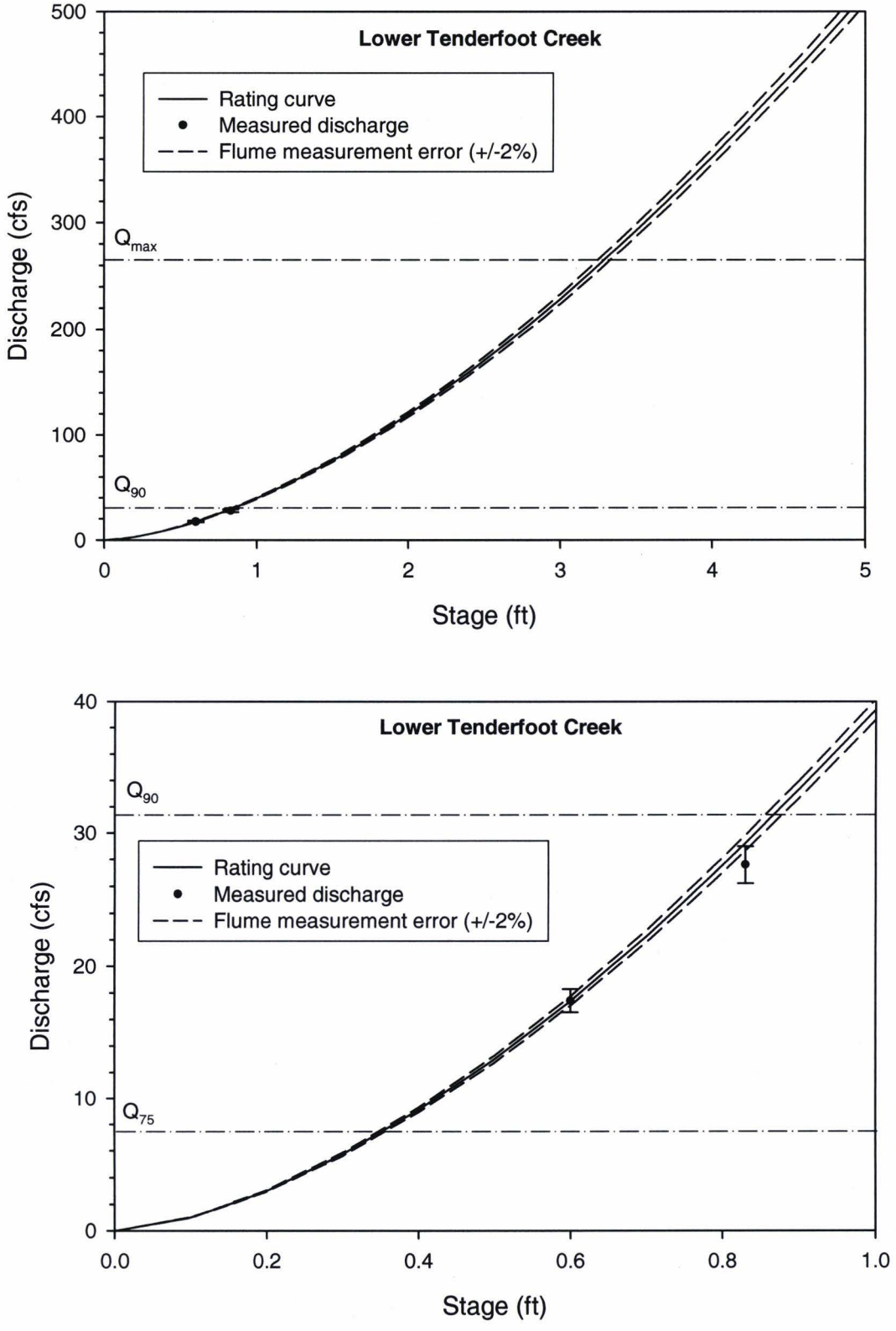


Figure 10. Stage rating curve and measured flows at Lower Sun Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

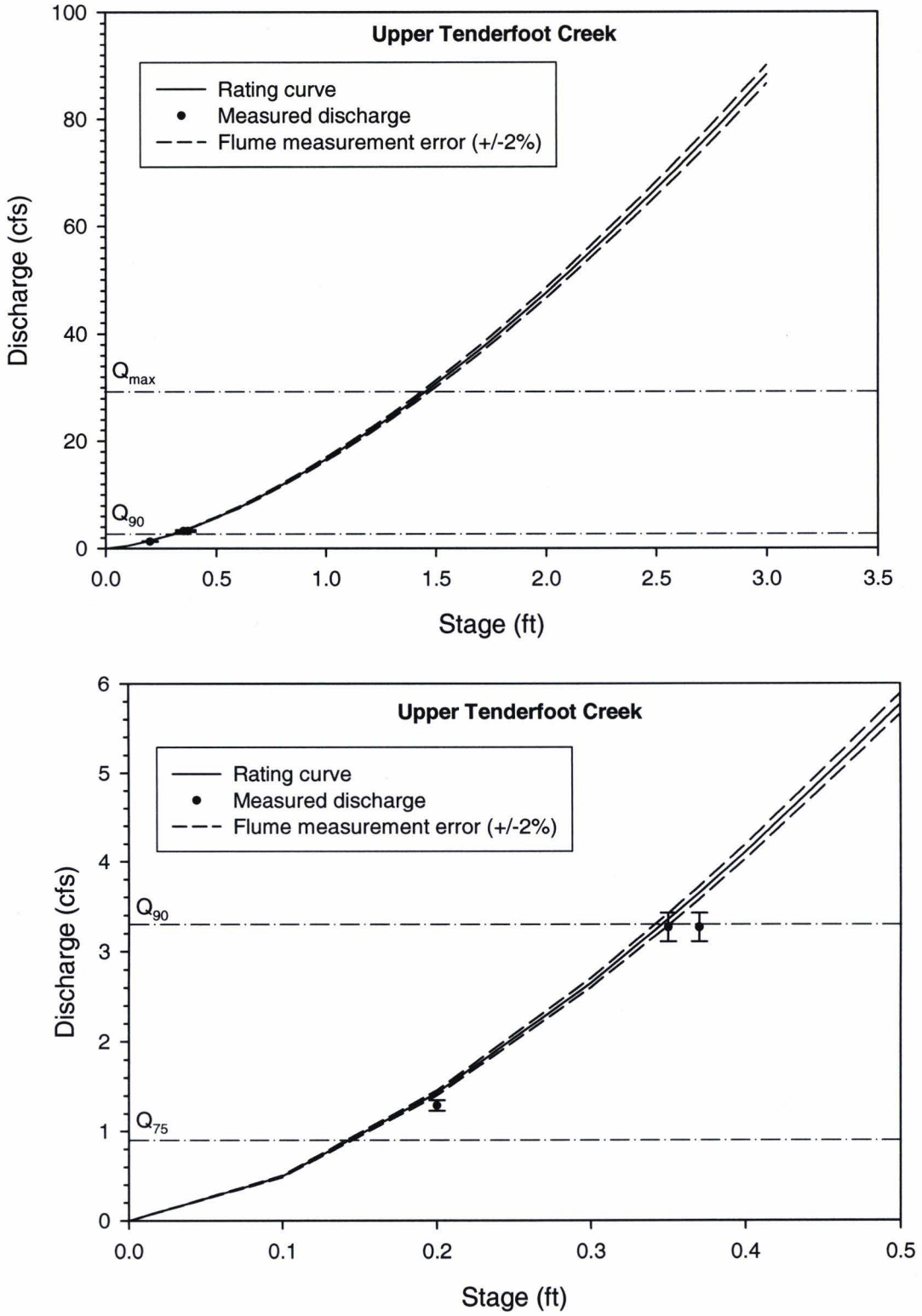
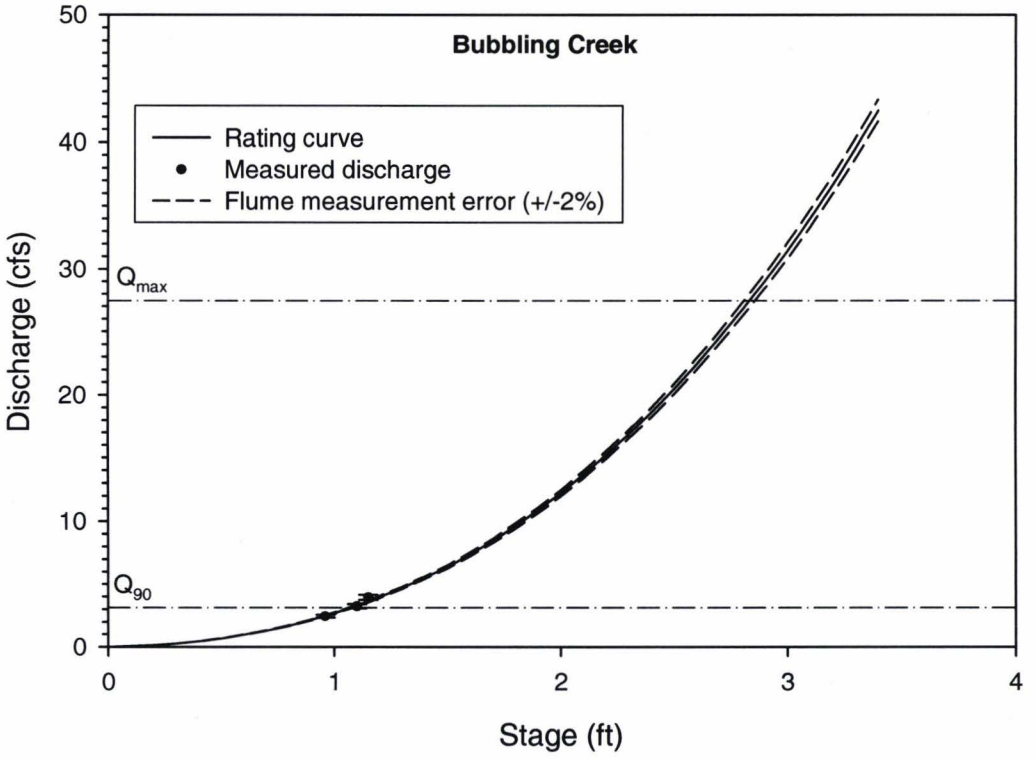


Figure 11. Stage rating curve and measured flows at Upper Tenderfoot Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.



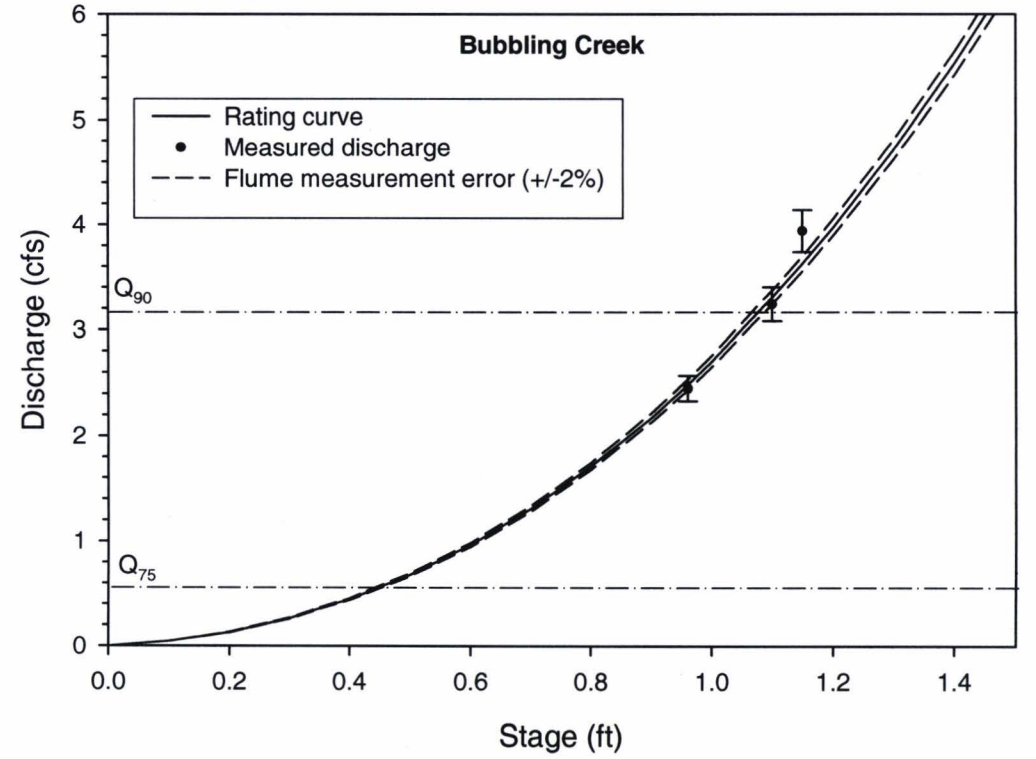


Figure 12. Stage rating curve and measured flows at Bubbling Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

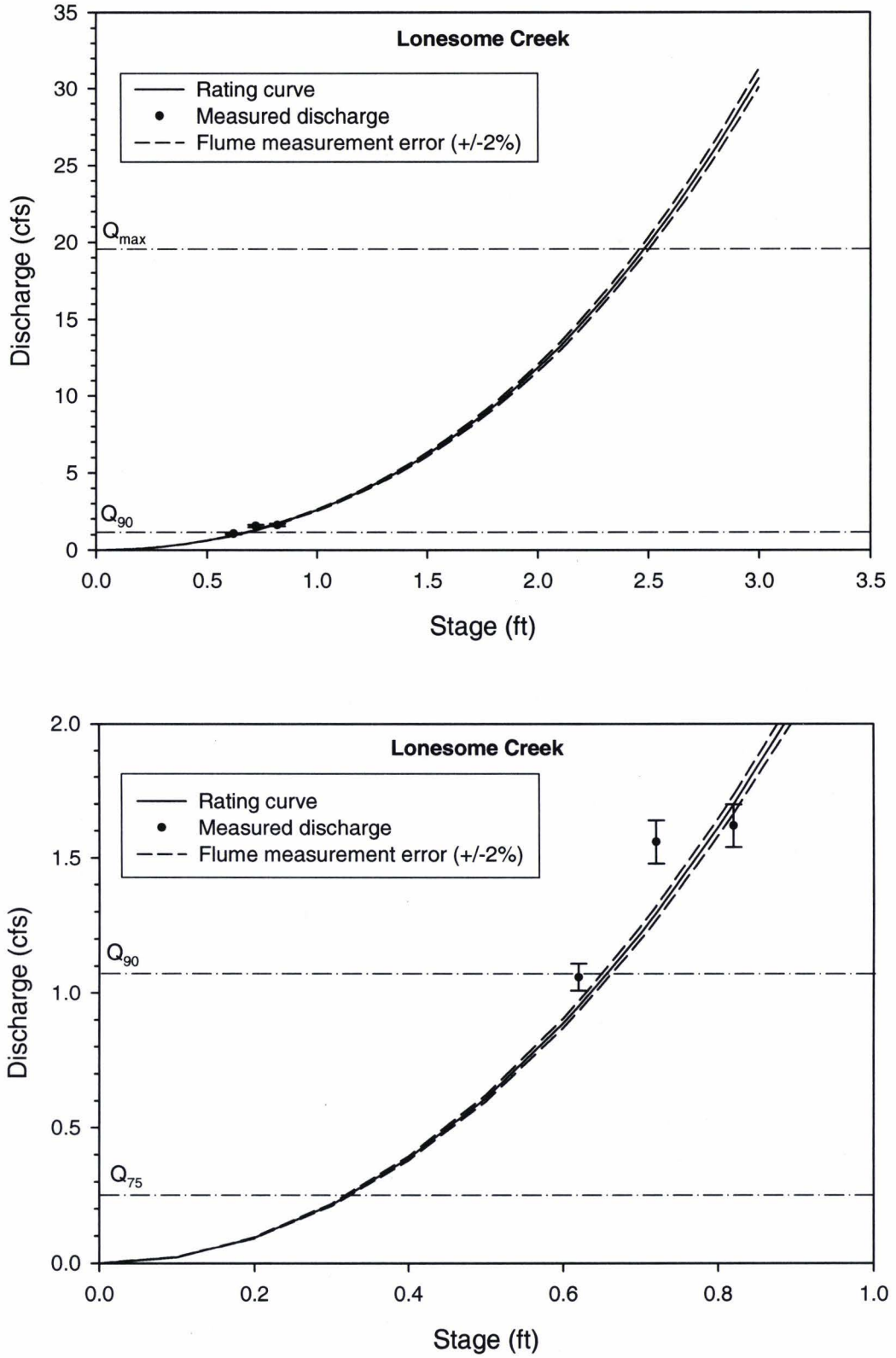


Figure 13. Stage rating curve and measured flows at Lonesome Creek. Error in flume measurements (indicated by dashed lines) is ±2% and error in discharge measurements (indicated by error bars) is ±5%. Q_{75} and Q_{90} are the 75th and 90th percentile mean daily flows and Q_{max} is the highest mean daily flow.

APPENDIX I

EXISTING RATING TABLES FOR FLUMES AT TENDERFOOT CREEK EXPERIMENTAL FOREST

RATING TABLE

PACK CREEK NEAR MOUTH
2-FOOT PARSHALL FLUME WITH EXTENDED SIDE WALLS - STAFF GAGE IN FEET

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
0.1	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
0.2	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.2
0.3	1.2	1.3	1.4	1.4	1.5	1.6	1.6	1.7	1.8	1.9
0.4	1.9	2.0	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.6
0.5	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.4	3.5
0.6	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5
0.7	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.6
0.8	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.6	6.7
0.9	6.8	6.9	7.0	7.2	7.3	7.4	7.5	7.6	7.8	7.9
1.0	8.0	8.1	8.2	8.4	8.5	8.6	8.8	8.9	9.0	9.1
1.1	9.3	9.4	9.5	9.7	9.8	9.9	10.1	10.2	10.3	10.5
1.2	10.6	10.8	10.9	11.0	11.2	11.3	11.5	11.6	11.7	11.9
1.3	12.0	12.2	12.3	12.4	12.6	12.7	12.9	13.0	13.2	13.3
1.4	13.5	13.6	13.8	13.9	14.1	14.2	14.4	14.5	14.7	14.9
1.5	15.0	15.2	15.3	15.5	15.6	15.8	15.9	16.1	16.3	16.4
1.6	16.6	16.7	16.9	17.1	17.2	17.4	17.6	17.7	17.9	18.0
1.7	18.2	18.4	18.5	18.7	18.9	19.0	19.2	19.4	19.6	19.7
1.8	19.9	20.1	20.2	20.4	20.6	20.8	20.9	21.1	21.3	21.5
1.9	21.6	21.8	22.0	22.2	22.4	22.5	22.7	22.9	23.1	23.2
2.0	23.4	23.6	23.8	24.0	24.2	24.3	24.5	24.7	24.9	25.1
2.1	25.3	25.5	25.6	25.8	26.0	26.2	26.4	26.6	26.8	27.0
2.2	27.2	27.3	27.5	27.7	27.9	28.1	28.3	28.5	28.7	28.9
2.3	29.1	29.3	29.5	29.7	29.9	30.1	30.3	30.5	30.7	30.9
2.4	31.1	31.3	31.5	31.7	31.9	32.1	32.3	32.5	32.7	32.9
2.5	33.1	33.3	33.5	33.7	33.9	34.2	34.4	34.6	34.8	35.0
2.6	35.2	35.4	35.6	35.8	36.0	36.2	36.5	36.7	36.9	37.1
2.7	37.3	37.5	37.7	38.0	38.2	38.4	38.6	38.9	39.1	39.3
2.8	39.5	39.7	40.0	40.2	40.4	40.6	40.8	41.1	41.3	41.5
2.9	41.7	42.0	42.2	42.4	42.6	42.9	43.1	43.3	43.6	43.8
3.0	44.0	44.2	44.5	44.7	44.9	45.1	45.4	45.6	45.8	46.0

FILE = C:\DATAFILES\TCEF\DATA\STREAMS\TABLES\PACK_NEW.TBL

RATING TABLE

PASSIONATE CREEK NEAR MOUTH
4-FOOT CIPOLLETTI WEIR
STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4
0.1	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0	1.1
0.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1
0.3	2.2	2.3	2.4	2.5	2.6	2.8	2.9	3.0	3.1	3.2
0.4	3.4	3.5	3.6	3.7	3.9	4.0	4.1	4.3	4.4	4.6
0.5	4.7	4.8	5.0	5.1	5.3	5.4	5.6	5.7	5.9	6.0
0.6	6.2	6.3	6.5	6.6	6.8	7.0	7.1	7.3	7.4	7.6
0.7	7.8	7.9	8.1	8.3	8.4	8.6	8.8	9.0	9.2	9.3
0.8	9.5	9.7	9.9	10.0	10.2	10.4	10.6	10.8	11.0	11.2
0.9	11.4	11.6	11.7	11.9	12.1	12.3	12.5	12.7	12.9	13.1
1.0	13.3	13.5	13.7	13.9	14.1	14.4	14.6	14.8	15.0	15.2
1.1	15.4	15.6	15.8	16.0	16.3	16.5	16.7	16.9	17.1	17.4
1.2	17.6	17.8	18.0	18.3	18.5	18.7	19.0	19.2	19.4	19.6
1.3	19.9	20.1	20.4	20.6	20.8	21.1	21.3	21.5	21.8	22.0
1.4	22.3	22.5	22.8	23.0	23.2	23.5	23.8	24.0	24.2	24.5
1.5	24.8	25.1	25.4	25.6	25.9	26.2	26.4	26.7	27.0	27.2
1.6	27.5	27.8	28.0	28.3	28.6	28.9	29.2	29.4	29.7	30.0
1.7	30.3	30.6	30.8	31.1	31.4	31.7	32.0	32.3	32.6	32.8
1.8	33.1	33.4	33.7	34.0	34.3	34.6	34.9	35.2	35.5	35.8
1.9	36.1	36.4	36.7	37.0	37.3	37.6	37.9	38.2	38.5	38.8
2.0	39.2	39.0	39.9	40.3	40.7	41.1	41.4	41.8	42.2	42.6
2.1	43.0	43.4	43.8	44.2	44.6	45.0	45.4	45.8	46.2	46.6
2.2	46.9	47.3	47.7	48.1	48.5	48.9				

4 ft Cipolletti up to 2.0 staff; then 5.79 ft rectangular weir up to 2.25 ft staff. Flume overtops @ 2.25 ft staff.
FILE = C:\DATAFILES\TCEF\DATA\STREAMS\TABLES\PASS_NEW.TBL

RATING TABLE

STRINGER CREEK NEAR MOUTH
4 FOOT H-FLUME - STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5
0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7
0.5	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0
0.6	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4
0.7	1.4	1.4	1.5	1.5	1.6	1.7	1.6	1.7	1.7	1.8
0.8	1.8	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.3
0.9	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.8
1.0	2.9	2.9	3.0	3.0	3.1	3.2	3.2	3.3	3.4	3.4
1.1	3.5	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.03	4.10
1.2	4.2	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9
1.3	4.9	5.0	5.1	5.2	5.3	5.4	5.4	5.5	5.6	5.7
1.4	5.8	5.9	6.0	6.0	6.1	6.2	6.3	6.4	6.5	6.6
1.5	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6
1.6	7.7	7.8	7.9	8.0	8.1	8.2	8.4	8.5	8.6	8.7
1.7	8.8	8.9	9.0	9.2	9.3	9.4	9.5	9.6	9.7	9.8
1.8	10.0	10.1	10.2	10.4	10.5	10.6	10.7	10.9	11.0	11.1
1.9	11.3	11.4	11.5	11.7	11.8	11.9	12.1	12.2	12.3	12.5
2.0	12.6	12.8	12.9	13.0	13.2	13.3	13.5	13.6	13.8	13.9
2.1	14.18	14.2	14.4	14.5	14.7	14.8	15.0	15.2	15.3	15.5
2.2	15.6	15.8	16.0	16.1	16.3	16.4	16.6	16.8	17.0	17.1
2.3	17.3	17.5	17.6	17.8	18.0	18.2	18.3	18.5	18.7	18.9
2.4	19.1	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.5	20.7
2.5	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.7
2.6	22.9	23.1	23.3	23.5	23.7	23.9	24.1	24.4	24.6	24.8
2.7	25.0	25.2	25.4	25.6	25.9	26.1	26.3	26.5	26.7	27.0
2.8	27.2	27.4	27.6	27.9	28.1	28.3	28.6	28.8	29.0	29.3
2.9	29.5	29.8	30.0	30.2	30.5	30.7	31.0	31.2	31.5	31.7
3.0	32.0	32.2	32.5	32.7	33.0	33.2	33.5	33.7	34.0	34.3

RATING TABLE

STRINGER CREEK RATING TABLE (continued)

DISCHARGE OF A 4-FT H-FLUME, CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
3.1	34.5	34.8	35.0	35.3	35.6	35.8	36.1	36.4	36.7	36.9
3.2	37.2	37.5	37.8	38.0	38.3	38.6	38.9	39.2	39.5	39.8
3.3	40.0	40.3	40.6	40.9	41.2	41.5	41.8	42.1	42.4	42.7
3.4	43.0	43.3	43.6	43.9	44.2	44.5	44.8	45.2	45.5	45.8
3.5	46.1	46.4	46.7	47.0	47.4	47.7	48.0	48.3	48.7	49.0
3.6	49.3	49.7	50.0	50.3	50.7	51.0	51.3	51.7	52.0	52.4
3.7	52.7	53.0	53.4	53.7	54.1	54.4	54.8	55.2	55.5	55.9
3.8	56.2	56.6	57.0	57.3	57.7	58.0	58.4	58.8	59.2	59.5
3.9	59.9	60.3	60.7	61.0	61.4	61.8	62.2	62.6	63.0	63.4
4.0	63.7									

FILE = C:\DATAFILE\TCEF\DATA\STREAMS\TABLES\STRINGER.TBL

RATING TABLE

STRINGER CREEK ABOVE EAST FORK
3.5 FOOT H-FLUME - STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
0.5	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9
0.6	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.3
0.7	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.7
0.8	1.7	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.1
0.9	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6
1.0	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.2	3.2
1.1	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9
1.2	4.0	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	4.6
1.3	4.7	4.8	4.9	4.9	5.0	5.1	5.2	5.3	5.4	5.4
1.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.2	6.3
1.5	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3
1.6	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.4
1.7	8.5	8.6	8.7	8.8	8.9	9.0	9.2	9.3	9.4	9.5
1.8	9.6	9.8	9.9	10.0	10.1	10.2	10.4	10.5	10.6	10.7
1.9	10.9	11.0	11.1	11.3	11.4	11.5	11.7	11.8	11.9	12.1
2.0	12.2	12.4	12.5	12.6	12.8	12.9	13.1	13.2	13.4	13.5
2.1	13.6	13.8	14.0	14.1	14.2	14.4	14.6	14.7	14.9	15.0
2.2	15.2	15.3	15.5	15.7	15.8	16.0	16.2	16.3	16.5	16.6
2.3	16.8	17.0	17.2	17.3	17.5	17.7	17.8	18.0	18.2	18.4
2.4	18.6	18.7	18.9	19.1	19.3	19.5	19.7	19.8	20.0	20.2
2.5	20.4	20.6	20.8	21.0	21.2	21.4	21.6	21.8	22.0	22.2
2.6	22.4	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.0	24.2
2.7	24.5	24.7	24.9	25.1	25.3	25.5	25.8	26.0	26.2	26.4
2.8	26.6	26.9	27.1	27.3	27.6	27.8	28.0	28.3	28.5	28.7
2.9	29.0	29.2	29.4	29.7	29.9	30.2	30.4	30.7	30.9	31.2
3.0	31.4	31.7	31.9	32.2	32.4	32.7	32.9	33.2	33.5	33.7
3.1	34.0	34.2	34.5	34.8	35.1	35.3	35.6	35.9	36.1	36.4
3.2	36.7	37.0	37.2	37.5	37.8	38.1	38.4	38.7	39.0	39.2
3.3	39.5	39.8	40.1	40.4	40.7	41.0	41.3	41.6	41.9	42.2
3.4	42.5	42.8	43.1	43.4	43.7	44.0	44.3	44.6	44.9	45.2

FILE = C:\DATAFILES\TCEF\DATA\STREAMS\TABLES\UPST_NEW.TBL

RATING TABLE

SPRING PARK CREEK NEAR MOUTH
2.5 FOOT PARSHALL FLUME - STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3
0.1	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8
0.2	0.8	0.9	0.9	1.0	1.1	1.2	1.2	1.3	1.4	1.4
0.3	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.1	2.2	2.3
0.4	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3
0.5	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.2	4.3	4.4
0.6	4.5	4.6	4.8	4.9	5.0	5.1	5.2	5.4	5.5	5.6
0.7	5.7	5.9	6.0	6.1	6.2	6.4	6.5	6.6	6.8	6.9
0.8	7.1	7.2	7.3	7.5	7.6	7.8	7.9	8.0	8.2	8.3
0.9	8.5	8.6	8.8	8.9	9.1	9.2	9.4	9.5	9.7	9.8
1.0	10.0	10.2	10.3	10.5	10.6	10.8	11.0	11.1	11.3	11.4
1.1	11.6	11.8	11.9	12.1	12.3	12.4	12.6	12.8	12.9	13.1
1.2	13.3	13.5	13.6	13.8	14.0	14.2	14.3	14.5	14.7	14.9
1.3	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.3	16.5	16.7
1.4	16.9	17.1	17.3	17.5	17.6	17.8	18.0	18.2	18.4	18.6
1.5	18.8	19.0	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.6
1.6	20.8	21.0	21.2	21.4	21.6	21.8	22.0	22.2	22.4	22.7
1.7	22.9	23.1	23.3	23.5	23.7	23.9	24.1	24.4	24.6	24.8
1.8	25.0	25.2	25.4	25.6	25.9	26.1	26.3	26.5	26.8	27.0
1.9	27.2	27.4	27.6	27.9	28.1	28.3	28.5	28.8	29.0	29.2
2.0	29.5	29.7	29.9	30.2	30.4	30.6	30.8	31.1	31.3	31.5
2.1	31.8	32.0	32.3	32.5	32.7	33.0	33.2	33.4	33.7	33.9
2.2	34.2	34.4	34.7	34.9	35.2	35.4	35.6	35.9	36.1	36.4
2.3	36.6	36.9	37.1	37.4	37.6	37.9	38.1	38.4	38.6	38.9
2.4	39.1	39.4	39.6	39.9	40.2	40.4	40.7	40.9	41.2	41.4
2.5	41.7	42.0	42.2	42.5	42.8	43.0	43.3	43.6	43.8	44.1

FILE = D:\TCEF\DATA\STREAMS\TABLES\SPRING.TBL

RATING TABLE

SUN CREEK NEAR MOUTH
4 FOOT PARSHALL FLUME - STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.0	0.1	0.10	0.10	0.2	0.2	0.3	0.3	0.4
0.1	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2
0.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.3
0.3	2.4	2.5	2.6	2.8	2.9	3.0	3.2	3.3	3.5	3.6
0.4	3.8	3.9	4.1	4.2	4.4	4.5	4.7	4.9	5.0	5.2
0.5	5.4	5.5	5.7	5.9	6.0	6.2	6.4	6.6	6.8	7.0
0.6	7.2	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9
0.7	9.1	9.3	9.5	9.7	10.0	10.2	10.4	10.6	10.8	11.0
0.8	11.2	11.5	11.7	11.9	12.2	12.4	12.6	12.8	13.1	13.3
0.9	13.6	13.8	14.0	14.3	14.5	14.8	15.0	15.2	15.5	15.8
1.0	16.0	16.2	16.5	16.8	17.0	17.3	17.5	17.8	18.1	18.3
1.1	18.6	18.9	19.1	19.4	19.7	20.0	20.2	20.5	20.8	21.0
1.2	21.3	21.6	21.9	22.2	22.5	22.8	23.0	23.3	23.6	23.9
1.3	24.2	24.5	24.8	25.1	25.4	25.7	26.0	26.3	26.6	26.9
1.4	27.2	27.5	27.8	28.1	28.4	28.8	29.1	29.4	29.7	30.0
1.5	30.3	30.7	31.0	31.3	31.6	32.0	32.3	32.6	32.9	33.3
1.6	33.6	33.9	34.2	34.6	34.9	35.3	35.6	35.9	36.3	36.6
1.7	37.0	37.3	37.6	38.0	38.3	38.7	39.0	39.4	39.7	40.1
1.8	40.4	40.8	41.2	41.5	41.9	42.2	42.6	43.0	43.3	43.7
1.9	44.0	44.4	44.8	45.2	45.5	45.9	46.3	46.6	47.0	47.4
2.0	47.8	48.1	48.5	48.9	49.3	49.7	50.0	50.4	50.8	51.2
2.1	51.6	52.0	52.4	52.8	53.1	53.5	53.9	54.3	54.7	55.1
2.2	55.5	55.9	56.3	56.7	57.1	57.5	57.9	58.3	58.7	59.1
2.3	59.6	60.0	60.4	60.8	61.2	61.6	62.0	62.4	62.8	63.3
2.4	63.7	64.1	64.5	64.9	65.4	65.8	66.2	66.6	67.1	67.5
2.5	67.9	68.4	68.8	69.2	69.7	70.1	70.5	71.0	71.4	71.8
2.6	72.2	72.7	73.1	73.6	74.0	74.5	74.9	75.4	75.8	76.2
2.7	76.7	77.1	77.6	78.0	78.5	79.0	79.4	79.9	80.3	80.8
2.8	81.2	81.7	82.1	82.6	83.1	83.5	84.0	84.4	84.9	85.4
2.9	85.8	86.3	86.8	87.3	87.7	88.2	88.7	89.1	89.6	90.1
3.0	90.6	91.0	91.5	92.0	92.5	93.0	93.4	93.9	94.4	94.9

LE = C:\DATAFILES\TCEF\DATA\STREAMS\TABLES\SUN_CREK.TBL

RATING TABLE

UPPER SUN CREEK AT ROAD CROSSING
STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.4	0.9	.11	.13	.15	.17	.19	.22	.25	.27	.30
0.5	.32	.36	.41	.45	.50	.55	.61	.68	.76	.84
0.6	.92	1.00	1.08	1.16	1.24	1.32	1.41	1.50	1.60	1.70
0.7	1.80	1.90	2.00	2.10	2.20	2.30	2.41	2.52	2.63	2.74
0.8	2.86	2.98	3.10	3.23	3.35	3.48	3.61	3.75	3.88	4.01
0.9	4.14	4.28	4.43	4.58	4.74	4.90	5.05	5.21	5.36	5.52
1.0	5.67									

RATING TABLE

TENDERFOOT CREEK BELOW STRINGER CREEK
10-FOOT PARSHALL FLUME - STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.1	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6
0.2	2.8	3.0	3.3	3.6	3.8	4.1	4.4	4.7	5.0	5.3
0.3	5.6	6.0	6.3	6.7	7.0	7.4	7.7	8.0	8.3	8.7
0.4	9.1	9.5	9.8	10.2	10.6	11.0	11.4	11.8	12.2	12.6
0.5	13.0	13.4	13.8	14.3	14.7	15.1	15.6	16.0	16.5	16.9
0.6	17.4	17.8	18.3	18.8	19.3	19.8	20.2	20.8	21.2	21.8
0.7	22.2	22.8	23.3	23.8	24.3	24.8	25.4	25.9	26.5	27.0
0.8	27.6	28.1	28.7	29.2	29.8	30.4	30.9	31.5	32.1	32.7
0.9	33.3	33.9	34.5	35.1	35.7	36.3	36.9	37.5	38.1	38.8
1.0	39.4	40.0	40.6	41.3	41.9	42.6	43.2	43.9	44.5	45.2
1.1	45.9	46.5	47.2	47.9	48.6	49.3	49.9	50.6	51.3	52.0
1.2	52.7	53.4	54.1	54.8	55.9	56.3	57.0	57.7	58.4	59.2
1.3	59.9	60.6	61.4	62.1	62.9	63.6	64.4	65.2	65.9	66.7
.4	67.4	68.2	69.0	69.8	70.6	71.4	72.1	72.9	73.7	74.5
.5	75.3	76.2	76.9	77.8	78.6	79.4	80.2	81.0	81.9	82.7
1.6	83.5	84.4	85.2	86.0	86.9	87.7	88.6	89.5	90.3	91.2
1.7	92.0	92.9	93.8	94.7	95.5	96.4	97.3	98.2	99.1	99.9
1.8	100.8	101.8	102.6	103.6	104.5	105.4	106.3	107.2	108.1	109.0
1.9	110.	110.9	111.8	112.8	113.7	114.6	115.6	116.5	117.5	118.4
2.0	119.4	120.3	121.3	122.3	123.2	124.2	125.2	126.1	127.1	128.1
2.1	129.1	130.1	131.0	132.0	133.0	134.0	135.0	136.0	137.0	138.0
2.2	139.0	140.0	141.1	142.1	143.1	144.1	145.2	146.2	147.2	148.2
2.3	149.3	150.3	151.4	152.4	153.5	154.5	155.6	156.6	157.7	158.7
2.4	159.8	160.8	161.9	163.0	164.1	165.2	166.2	167.3	168.4	169.5
2.5	170.6	171.7	172.8	173.9	175.0	176.1	177.2	178.3	179.4	180.5
2.6	181.6	182.8	183.9	185.0	186.2	187.3	188.4	189.6	190.7	191.8
2.7	192.9	194.1	195.2	196.4	197.6	198.7	199.9	201.0	202.2	203.4
2.8	204.5	205.7	206.8	208.0	209.2	210.4	211.6	212.8	213.9	215.1
2.9	216.3	217.5	218.7	219.9	221.1	222.3	223.5	224.8	226.0	227.2

RATING TABLE

TENDERFOOT CREEK BELOW STRINGER CREEK (continued)

DISCHARGE OF A 10 FT PARSHALL FLUME, CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
3.0	228.4	229.6	230.8	232.0	233.3	234.5	235.7	237.0	238.2	239.4
3.1	240.7	241.9	243.2	244.4	245.7	246.9	248.2	249.4	250.7	251.9
3.2	253.2	254.5	255.7	257.0	258.3	259.6	260.9	262.1	263.4	264.7
3.3	266.0	267.3	268.6	269.9	271.2	272.5	273.8	275.1	276.4	277.7
3.4	279.0	280.3	281.6	283.0	284.3	285.6	286.9	288.2	289.6	290.9
3.5	292.2	293.6	294.9	296.3	297.6	299.0	300.3	301.7	303.0	304.4
3.6	305.7	307.1	308.4	309.8	311.2	312.6	313.9	315.3	316.7	318.0
3.7	319.4	320.8	322.2	323.6	325.0	326.4	327.8	329.1	330.5	331.9
3.8	333.3	334.7	336.1	337.5	339.0	340.4	341.8	343.2	344.6	346.1
3.9	347.5	348.9	350.3	351.8	353.2	354.7	356.1	357.5	359.0	360.4
4.0	361.9	363.3	364.8	366.2	367.7	369.2	370.6	372.1	373.5	375.0
4.1	376.5	377.9	379.4	380.9	382.4	383.8	385.3	386.8	388.3	389.8
[illegible]	391.2	392.7	394.2	395.8	397.3	398.8	400.3	401.8	403.3	404.8
4.3	406.3	407.8	409.4	410.9	412.4	413.9	415.4	416.9	418.4	419.9
4.4	421.4	423.0	424.5	426.1	427.6	429.2	430.7	432.3	433.8	435.4
4.5	436.9	438.4	440.0	441.6	443.1	444.7	446.2	447.8	449.4	450.9
4.6	452.5	454.1	455.7	457.2	458.8	460.4	462.0	463.6	465.2	466.7
4.7	468.3	469.9	471.5	473.2	474.8	476.4	478.0	479.6	481.2	482.8
4.8	484.4	486.0	487.6	489.3	490.9	492.5	494.1	495.8	497.4	499.0
4.9	500.6	502.3	503.9	505.6	507.2	508.9	510.5	512.1	513.8	515.4
5.0	517.1	518.7	520.4	522.1	523.7	525.4	527.1	528.7	530.4	532.1

FILE = D:\TCEF\DATA\STREAMS\TABLES\LOWERTC.TBL

RATING TABLE

TENDERFOOT CREEK ABOVE SUN CREEK
4 FOOT PARSHALL FLUME - STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4
0.1	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2
0.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.3
0.3	2.4	2.5	2.6	2.8	2.9	3.0	3.2	3.3	3.5	3.6
0.4	3.8	3.9	4.1	4.2	4.4	4.5	4.7	4.9	5.0	5.2
0.5	5.4	5.5	5.7	5.9	6.0	6.2	6.4	6.6	6.8	7.0
0.6	7.2	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9
0.7	9.1	9.3	9.5	9.7	10.0	10.2	10.4	10.6	10.8	11.0
0.8	11.2	11.5	11.7	11.9	12.2	12.4	12.6	12.8	13.1	13.3
0.9	13.6	13.8	14.0	14.3	14.5	14.8	15.0	15.2	15.5	15.8
1.0	16.0	16.2	16.5	16.8	17.0	17.3	17.5	17.8	18.1	18.3
1.1	18.6	18.9	19.1	19.4	19.7	20.0	20.2	20.5	20.8	21.0
1.2	21.3	21.6	21.9	22.2	22.5	22.8	23.0	23.3	23.6	23.9
1.3	24.2	24.5	24.8	25.1	25.4	25.7	26.0	26.3	26.6	26.9
1.4	27.2	27.5	27.8	28.1	28.4	28.8	29.1	29.4	29.7	30.0
1.5	30.3	30.7	31.0	31.3	31.6	32.0	32.3	32.6	32.9	33.3
1.6	33.6	33.9	34.2	34.6	34.9	35.3	35.6	35.9	36.3	36.6
1.7	37.0	37.3	37.6	38.0	38.3	38.7	39.0	39.4	39.7	40.1
1.8	40.4	40.8	41.2	41.5	41.9	42.2	42.6	43.0	43.3	43.7
1.9	44.0	44.4	44.8	45.2	45.5	45.9	46.3	46.6	47.0	47.4
2.0	47.8	48.1	48.5	48.9	49.3	49.7	50.0	50.4	50.8	51.2
2.1	51.6	52.0	52.4	52.8	53.1	53.5	53.9	54.3	54.7	55.1
2.2	55.5	55.9	56.3	56.7	57.1	57.5	57.9	58.3	58.7	59.1
2.3	59.6	60.0	60.4	60.8	61.2	61.6	62.0	62.4	62.8	63.3
2.4	63.7	64.1	64.5	64.9	65.4	65.8	66.2	66.6	67.1	67.5
2.5	67.9	68.4	68.8	69.2	69.7	70.1	70.5	71.0	71.4	71.8
2.6	72.2	72.7	73.1	73.6	74.0	74.5	74.9	75.4	75.8	76.2
2.7	76.7	77.1	77.6	78.0	78.5	79.0	79.4	79.9	80.3	80.8
2.8	81.2	81.7	82.1	82.6	83.1	83.5	84.0	84.4	84.9	85.4
2.9	85.8	86.3	86.8	87.3	87.7	88.2	88.7	89.1	89.6	90.1
3.0	90.6	91.0	91.5	92.0	92.5	93.0	93.4	93.9	94.4	94.9

FILE = C:\DATAFILES\TCEF\DATA\STREAMS\TABLES\UPPERTC.TBL

RATING TABLE

BUBBLING CREEK NEAR MOUTH
3.5 FOOT H-FLUME - STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
0.5	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9
0.6	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.3
0.7	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.7
0.8	1.7	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.1
0.9	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6
1.0	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.2	3.2
1.1	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9
1.2	4.0	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	4.6
1.3	4.7	4.8	4.9	4.9	5.0	5.1	5.2	5.3	5.4	5.4
1.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.2	6.3
1.5	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3
1.6	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.4
1.7	8.5	8.6	8.7	8.8	8.9	9.0	9.2	9.3	9.4	9.5
1.8	9.6	9.8	9.9	10.0	10.1	10.2	10.4	10.5	10.6	10.7
1.9	10.9	11.0	11.1	11.3	11.4	11.5	11.7	11.8	11.9	12.1
2.0	12.2	12.4	12.5	12.6	12.8	12.9	13.1	13.2	13.4	13.5
2.1	13.6	13.8	14.0	14.1	14.2	14.4	14.6	14.7	14.9	15.0
2.2	15.2	15.3	15.5	15.7	15.8	16.0	16.2	16.3	16.5	16.6
2.3	16.8	17.0	17.2	17.3	17.5	17.7	17.8	18.0	18.2	18.4
2.4	18.6	18.7	18.9	19.1	19.3	19.5	19.7	19.8	20.0	20.2
2.5	20.4	20.6	20.8	21.0	21.2	21.4	21.6	21.8	22.0	22.2
2.6	22.4	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.0	24.2
2.7	24.5	24.7	24.9	25.1	25.3	25.5	25.8	26.0	26.2	26.4
2.8	26.6	26.9	27.1	27.3	27.6	27.8	28.0	28.3	28.5	28.7
2.9	29.0	29.2	29.4	29.7	29.9	30.2	30.4	30.7	30.9	31.2
3.0	31.4	31.7	31.9	32.2	32.4	32.7	32.9	33.2	33.5	33.7
3.1	34.0	34.2	34.5	34.8	35.1	35.3	35.6	35.9	36.1	36.4
3.2	36.7	37.0	37.2	37.5	37.8	38.1	38.4	38.7	39.0	39.2
3.3	39.5	39.8	40.1	40.4	40.7	41.0	41.3	41.6	41.9	42.2
3.4	42.5	42.8	43.1	43.4	43.7	44.0	44.3	44.6	44.9	45.2

FILE = C:\DATAFILES\TCEF\DATA\STREAMS\TABLES\BUBBLING.TBL

RATING TABLE

LONESOME CREEK NEAR WILLIAMS PARK
3 FOOT H-FLUME - STAFF GAGE IN FEET, DISCHARGE IN CFS

Staff	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.03
0.1	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.09	0.09	0.10
0.2	0.11	0.12	0.13	0.14	0.16	0.17	0.18	0.19	0.21	0.22
0.3	0.23	0.25	0.26	0.28	0.30	0.31	0.33	0.35	0.36	0.38
0.4	0.40	0.42	0.44	0.46	0.48	0.50	0.53	0.55	0.57	0.60
0.5	0.62	0.64	0.67	0.70	0.72	0.75	0.78	0.80	0.83	0.86
0.6	0.89	0.92	0.95	0.98	1.01	1.05	1.08	1.11	1.15	1.18
0.7	1.22	1.25	1.29	1.33	1.36	1.40	1.44	1.48	1.52	1.56
0.8	1.60	1.65	1.69	1.73	1.78	1.82	1.86	1.91	1.96	2.00
0.9	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.41	2.46	2.51
1.0	2.57	2.62	2.68	2.73	2.79	2.85	2.91	2.97	3.03	3.09
1.1	3.15	3.21	3.27	3.34	3.40	3.46	3.53	3.60	3.66	3.73
1.2	3.80	3.87	3.94	4.01	4.08	4.15	4.23	4.30	4.37	4.45
1.3	4.53	4.60	4.68	4.76	4.84	4.92	5.00	5.08	5.16	5.24
1.4	5.33	5.41	5.50	5.58	5.67	5.76	5.84	5.93	6.02	6.11
1.5	6.20	6.30	6.39	6.48	6.58	6.67	6.77	6.87	6.96	7.06
1.6	7.16	7.26	7.36	7.47	7.57	7.67	7.78	7.88	7.99	8.10
1.7	8.20	8.31	8.42	8.53	8.64	8.75	8.87	8.98	9.10	9.21
1.8	9.33	9.45	9.56	9.68	9.80	9.92	10.05	10.17	10.29	10.41
1.9	10.50	10.64	10.78	10.92	11.06	11.20	11.34	11.48	11.62	11.76
2.0	11.90	12.04	12.18	12.32	12.46	12.60	12.74	12.88	13.02	13.16
2.1	13.30	13.45	13.60	13.75	13.90	14.05	14.20	14.35	14.50	14.65
2.2	14.80	14.96	15.12	15.28	15.44	15.60	15.76	15.92	16.08	16.24
2.3	16.40	16.57	16.74	16.91	17.08	17.25	17.42	17.59	17.76	17.93
2.4	18.10	18.28	18.46	18.64	18.82	19.00	19.18	19.36	19.54	19.72
2.5	19.90	20.10	20.30	20.50	20.70	20.90	21.10	21.30	21.50	21.70
2.6	21.90	22.10	22.30	22.50	22.70	22.90	23.10	23.30	23.50	23.70
2.7	23.90	24.11	24.32	24.53	24.74	24.95	25.16	25.37	25.58	25.79
2.8	26.00	26.23	26.46	26.69	26.92	27.15	27.38	27.61	27.84	28.07
2.9	28.30	28.54	28.78	29.02	29.26	29.50	29.74	29.98	30.22	30.46
3.0	30.70									

LE = C:\DATAFILES\TCEF\DATA\STREAMS\TABLES\LONESOME.TBL